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Extending OM configuration concepts

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Network configuration of global R&D networks: Extending OM configuration concepts

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Abstract

Companies are increasingly globalising their R&D activities, both within the firms and with external partners, with consequent implications for their interaction with manufacturing operations. Previous research in R&D networks has focused on coordination, governance and support elements. However, network configuration of global R&D has tended to focus on strategic elements with limited attention given operational effectiveness, or to interfaces with downstream manufacturing operations. Within OM literature, the drivers of configuration of global networks within, engineering, production, supply, and services have been extensively developed in recent years. This paper extends these OM configuration concepts to the configuration of R&D networks, to provide a more comprehensive strategic and operational analysis for this domain, and to also consider potential interfaces with manufacturing operations. The methodology involved developing a framework for R&D network configuration drawing on the approaches used in OM, followed by multiple case-studies to map R&D configuration elements.

The findings showed that while some elements were similar to previous network configuration research some new elements, specific to R&D networks emerged, e.g. product features were more prominent in R&D networks. Furthermore, the study has shown extensive interaction with other operations, including many downstream manufacturing operations. By extending the OM configuration concepts to the configuration of R&D networks this paper provides new insight into both R&D networks and OM configuration theories and thereby strengthens both academic fields.

Keywords: R&D networks, configuration, globalisation

Purpose

Companies are increasingly globalising their R&D activities through global networking and alliances with other firms around the globe (EIU, 2004; Trott, 2005; Hsuan & Mahnke, 2011). Configuration of R&D is a complex management task with particular R&D network forms having specific benefits and potential risks. Literature on R&D networks has focused on network structure, governance, and support infrastructure (e.g. Chaston, 1995; Biggiero, 2001; Halme and Fadeeva, 2001; Hammami et al., 2003, Fulop, 2000; Huggins, 2000; Sherer, 2003; Tell. 2000). There is a gap in the literature, however, on how R&D networks can be configured in a systematic way and how selection options might influence R&D capabilities. In OM literature by contrast, the concept of network configuration and design has been more recently explored and provides wider application across the manufacturing value chain. This paper explores how the configuration approach used in the OM and strategic management literature can inform the design and configuration of R&D networks. This paper seeks to understand how R&D network configuration and design choices influence similar configuration considerations in operations management. The use of configuration concepts from the OM literature to support the definition and design of R&D network configurations facilitates understanding of the interactions between R&D and operations by using a common architecture.

Background

Within a global company, which relies on technological innovation as a basis for market growth, R&D and operations need to interact to provide timely, efficient, innovative solutions. This is particularly difficult to achieve in fast-clock industries.

The configuration of international R&D networks has been studied from the dimension of geographic dispersion, coordination and direction of knowledge flows (Gassmann & von Zedtwitz, 1999; Kuemmerle, 1997; Miller & Morris, 1998).

Gassmann & von Zedtwitz (1999) classified R&D networks into five types by the dispersion of R&D activities and the degree of cooperation between R&D centres which each had certain advantages and disadvantages. These were:

1) Ethnocentric centralised
   - Characterised by a lack of translational R&D processes as all R&D activities are concentrated at the home base
2) Geocentric centralised
   - Created to overcome the lack of market sensitivity
3) Polycentric decentralised
   - Created to overcome the isolation of formerly independent R&D units and integrate them into a wider R&D network
4) R&D hub
   - Is usually a reaction by centralised companies to the internationalisation of resources
5) Integrated R&D network
   - In an integrated network authority for technology and component development are based on individual capabilities of the R&D units

Other aspects of R&D networks have also been analysed that focus on similar concepts to those considered in the OM literature. These include knowledge and technology transfer (Knudsen, 2007; Perks, 2000), relationship management (Boddy et al., 2000; Emden et al., 2006; Hsuan & Mahnke, 2011), location selection (Von Zedtwitz & Gassmann, 2002), joint R&D projects (Kurkkio, 2009) and strategic networks (Thorgren et al., 2009).

Strategic networks allow companies to exchange ideas, knowledge, or resources while maintaining independence in other areas. This exchange can be for product or process innovation or related to production or marketing. Literature within this area is therefore important to include when debating R&D networks. Strategic networks have been analysed using the learning organisation's concepts and the resource-based view (Ahlström-Söderling, 2003 and Tyler, 2001). Investigated areas include:

1. Network formation (Chaston, 1995; Biggiero, 2001; Ahlström-Söderling, 2003, Dean et al., 1997; Hanna and Walsh, 2002; Huggins, 2001)
2. Network capabilities and network gains (Brown and Butler, 1995; Dean et al. (1997; Fukugawa, 2006; Fuller-Love and Thomas, 2004; Halme and Fadeeva, 2001)
3. Network management and governance (Hammami et al., 2003, Ammenberg et al., 1999; Fulop, 2000; Huggins, 2000; Sherer, 2003; Tell. 2000)

But none gives a complete picture of R&D interactions with other functions.

Within strategic management literature, network configuration research has investigated organisational structure and how types of configuration (often depicted as organisational caricatures) are used in directing attitudes, attention, influence, resources, motivations, and effort (Chandler, 1962; Khandwalla, 1970; Rumelt, 1974; Miles and Snow, 1978; Miller, 1996). Configuration concepts were developed to include application and relevance to company strategy, company mission, strategic resources and target markets (Kotter, 1995; Miller, 1996; Mintzberg et al., 1998). These concepts are predominantly firm based, representing a firm's organisation (or system), its span of control, types of normalisation and decentralisation, and planning systems (Mintzberg et al., 1998).

Operations management literature have analysed global networks using two dimensions: the configuration and the coordination of the network due to Porter's separation of these in the value chain (Shi & Gregory, 1998; Porter, 1986; Cooper et al., 1997; Davidson & delaTorre, 1989). Particular supply network dimensions have been found to contribute to the development of supply network configuration theory. This includes the influence of product characteristics on supply network dynamics (Fisher, 1997; Christopher, 2000; Lamming et al., 2000). The influence on supply network operation of demand characteristics and supply characteristics (Mason-Jones et al., 2000) and supply uncertainty (Lee, 2002) introduce the dimensions of upstream and downstream network structure. The impact of product-price-stability (Srai and Mills, 2005) suggests product-life-cycle and the balance between supply-demand are relevant supply network configuration dimensions. Recent research (Fisher, 1997; Lamming et al.,2000; Lee, 2002; Klass, 2003; Srai and Mills, 2005) introduce supply network management approaches that address these particular operational dimensions. In this manner operations management literature builds supply network "profiles" based on alternative supply network management approaches. Key examples include alternative approaches to; managing complexity by differentiating competitive priorities (Lamming et al., 2000), managing supply uncertainty (Lee, 2002), enabling logistics processes (Klass, 2003), and supply-demand dynamics (Srai and Mills, 2005), with each providing some elements of supply network configuration. The emphasis is however on selective dimensions of interest rather than a comprehensive configurational analysis linking strategy, context, structure and capability. Srai and Gregory (2008) introduced a comprehensive configurational analysis framework for supply chain networks that enabled configuration profiling, with particular archetypes identified each linked to specific capabilities. Recent studies on network configurations within operations literature based on this framework have taken a structural approach; services (Srai, 2010), engineering (Zhang, Shi & Gregory, 2007), supply chain (Srai & Gregory 2008) and manufacturing (Shi & Gregory 1998; Christodoulou et al 2007). Srai and Fleet (2010) attempted to incorporate these into one framework. This framework describes how a global network's configuration consists of 6 elements:

- Network structure
- Network dynamics

- Governance and coordination
- Support infrastructure
- Network relationships
- Product configuration

This paper adopts these configuration elements of network configuration.

Extending this approach to the R&D domain and literature we can see that authors have investigated some aspects of these 6 configuration elements within R&D networks (see table 1). These also include knowledge and technology transfer, R&D project management, governance within R&D networks and relationship management for internal and external relationships.

Table 1 - R&D literature mapped to the network configuration approach

	Borch and Arthur (1995) Chen (1999)	Chen (1999) Wincent (2005)	Diez (2001)	Florén and Tell (2004) Major and Cordey-Hayes (2000) Tell. (2000)	Halme and Fadeeva (2001), Lichtenthaler, (2003); Söderlund, (2004), Dekker, (2004); Langfield-Smith and Smith, (2003)	Fulop (2000),	Sherer, (2003) Kurkkio, (2009)
Network structure		Regional policies		Relationship with stakeholders outside the R&D network	External relationships		
Network dynamics	Actor relationships			Knowledge sharing Technology transfer			
Governance and coordination	The influence of cultural elements			Degrees of trust	Degree of control and formalisation		
Support infrastructure					Information technology		
Network relationships	Company strategy interfirm relationships				Degree of formalisation between the network members		
Product configuration					Product and process complexity Technologies used		
Other areas					Contextual factors for the R&D project (e.g. size, perceived value)		

Aim

The research aims to extend the configurational approach from the strategic management and OM domains to R&D networks, to develop consistent terminology to span the full manufacturing value chain. This facilitates:

- A potentially more comprehensive definition of R&D configuration.
- One that can be aligned with the configuration of the operational network.

The ability to define the configuration for R&D and OM networks consistently may identify synergies, improve the overall coherence of the business model, and also reveal potential conflicts where common approaches may be required.

The research question is *“How can R&D network configurations be defined to explore potential interactions with the downstream operations network?”*

Methodology

This research design is based on the research framework developed by Blessing & Chakrabarti (2002) (see Figure 1), which includes a descriptive and a prescriptive phase. Both the present situation and possible improvements are uncovered which are key elements of the research aim

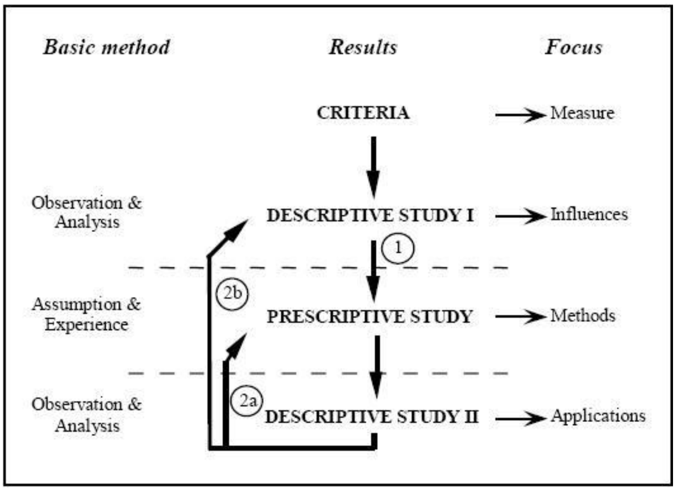

Figure 1 **-** *The research framework. Source: Blessing & Chakrabarti (2002)*

In the first phase an extensive literature review was carried out and a preliminary framework developed. In the second phase data was gathered from case companies to enrich and enhance this framework. In the third phase the framework was enriched with this input and in the last phase this framework was tested in industry.

The case study approach was selected as the most appropriate research method due to the complex and explorative nature of the research question as it allows for in-depth information. Case companies were selected based on certain criteria. These were that the company were an engineering company with a large R&D department, had a global footprint, were from different sectors to get breath and width in the dataset and that access to top managers was possible. Four Danish multinational engineering corporations were selected. The case companies were from different sectors and were among the largest engineering corporations in Denmark. All these corporations had slowly globalised more of their engineering network, starting with what they perceived as the least value adding activities. While global technology providers (e.g. universities, customers, suppliers) had been used for a long time these companies had in recent years started to globalise R&D activities through offshoring and outsourcing as a way to gain access to markets and unique capabilities while keeping costs down.

Interviewees were selected based on their experience with the company's R&D activities. Vice presidents and managers for all areas were interviewed to understand the connectivity of the R&D activities with other functional areas. Data was collected through semi-structured interviews and lasted between 1-2 hours. Additional information came from company documentation and public statements. All interviews were audio recorded and transcribed. Main data analysis approaches were coding (Strauss and Corbin, 1998) and pattern-matching (Yin, 1994).

This research is cross-disciplinary with focus on both technical and organisational aspects and is a result of a collaboration between two European based Universities.

Findings

The following table show the key findings from the four case companies (table 2).

Table 2 - Findings from the case studies

	Network structure and challenges	Supporting configuration dimensions
Case company 1 **Description**: A more than 100 years old formerly family owned enterprise which is world-leading in the cement industry	There are 4 global R&D centres located in the USA, India Denmark. Key challenges are to ensure coordination, knowledge sharing, communication and transparency. The product's features were vital in how these challenges were felt. A legacy of some of these centres having been created due to an M&A means some resentment and different work approaches exist. Due to a centralised history exploring local networks is slow. Local policy in India and an already established office there has meant the company have moved more than 80% of all engineering tasks and more than 15% of all R&D to India from other global offices, with more expected to follow. However, it is mainly the Danish headquarters which have contact with outside knowledge providers like Universities etc. The company keeps a small manufacturing site they own to be able to 'test' R&D ideas in practice after all other manufacturing were outsourced.	Knowledge sharing and communication are very important. Trust is a key element here which is influenced by company ownership and equality structures as well as understanding of local culture and work approaches. Local policy making and brown field sites for engineering also influence the structure of the R&D network. Product features were very important in regard to how easy it was to work on the product globally and how. Contact to manufacturing is important due to the large amount of parts which need to fit together in the final product. This interaction is thereby influenced by the product's features.
Case company 2 **Description**: A more than 100 years old company which is world-leading in the telecommunications industry	R&D is in Denmark and China with strategic partners in India. The relationship with the company in India is focused on competences and built on trust. Issues with the Chinese office include trust, knowledge sharing and coordination. Product features are important in how these issues were felt. The local network in China finds lower tier manufacturing suppliers. Contact to production and design engineers is important to ensure a fast development process with many iterations. Due to IP rights and focus on western customers, the earliest stages of R&D (idea generation and customer sales) remains in Denmark – as does contact with outside knowledge providers like Universities. Project features like size and perceived value influence work approach and interaction.	IP rights, trust and the market strategy influence the assignments and the power each unit has. Contact to outside knowledge providers often remains near the units located in the headquarters. Some R&D centres need communication and knowledge sharing with other areas like product designers and production engineers. Most manufacturing is outsourced but the company still owns a factory in China. Product features and project characteristics were very important in regard to how easy it was to work on the product globally and how.
Case company 3 **Description**: A sister company to a more than 100 years old family owned company which is world-leading as a engineering and consulting company within pharma and biotech.	Cultural differences make communication and knowledge sharing between the unit in China and Denmark difficult. Expatriates have been used as a temporary solution. Embeddedness of the company strategy relating to global R&D is low with several processes, including HR, working against it. Product features, including complexity and modularity, were important in determining how easy it was to work with the task in a global network. Contact with all stages of development is important to ensure the final product agrees with laws and regulations.	The level of embeddedness of the R&D strategy in organisational routines, processes and practices influence how well it is carried out on the operational level. Furthermore, the level of cultural difference between organisational units and groups play a key role in what knowledge is shared and how. Strict rules and laws in many countries regarding pharma and biotech means the company's development process is very integrated, from R&D to manufacturing.
Case company 4 **Description**: Started 30 years ago, this company is now world leading within renewable energy	Have R&D facilities in 7 countries. IP rights are an issue with the new Chinese facilities. Danish managers are used to safeguard information. They are thereby an 'isolated' part of the network. This limits communication, trust and knowledge sharing. Product features were important in determining collaboration and task assignments.	IP rights and trust can influence how work processes are carried out and what work is given to which unit in the network, the level of knowledge sharing and collaboration and thereby influence the degree of integration in the network.

The case studies showed that R&D networks can be effectively analysed and classified using the selected operations network configuration approach. While some of the findings were similar to previous analyses on global networks many were specific to R&D networks. Similarities to global engineering networks were especially noticeable in regard to its network dynamics while aspects of supply chain networks were relevant to network relationships as many global R&D networks included both internal and external stakeholders. Elements specific to R&D networks were the importance of product features and the contextual factors for the project (see table 3).

Table 3 - Findings from the case studies mapped to the OR configuration elements

	Compatible to OR configuration elements	Specific to R&D networks
Network structure	Geographical distribution of sites the company owns and the sites owned by third parties used by the company in their R&D process. The role each R&D centre plays in regard to which tasks it does.	Specific to R&D networks is that the company ownership and equality structures as well as local policy making also influence the structure of the network.
Network dynamics	R&D networks have several similarities to global engineering networks. One of the main similarities lies in the importance of knowledge exchange and communication flow and the operational processes for these.	Specific R&D related processes like innovation processes and idea generation are specific important elements for the network dynamics of an R&D network. R&D centres often need communication and knowledge sharing with other functions and areas like product designers and production engineers.
Governance and coordination	Like for other global networks coordination and trust between external and internal units are important elements.	Specific to R&D networks is the importance of the level of embeddedness of the R&D strategy in organisational routines, processes and practices. Furthermore, the level of cultural difference between organisational units and groups play a key role in what knowledge is shared and how.
Support infrastructure	Like for global engineering networks IT tools for knowledge sharing, collaboration and engineering are important.	However, specific to R&D networks is the importance of HR processes as these influences the level of knowledge sharing and collaboration and thereby influence the degree of integration in the network.
Network relationships	Similar to global manufacturing networks, intra-firm capability building is relevant to build on the internal knowledge base	Partnering strategies are important for managing outside knowledge providers.
Product configuration		The product's complexity, modularity, interfaces, lifecycle, maturity, universality and novelty. The risk of IP loss is specific to R&D networks.
Other areas		Contextual factors for the R&D project (e.g. size, perceived value)

Conclusion

This article expands on global R&D network literature by providing a detailed description of the configuration of global R&D networks. It expands understanding of OR network configuration by illustrating the specific elements relevant for R&D networks and the interaction between R&D and downstream operations.

The findings showed that some elements are similar to previously documented configurations on other global networks (e.g. communication and support tools) but others are new and specific to R&D networks (e.g. product features, IP issues). Furthermore, the study has shown extensive interaction with other operations, including many downstream manufacturing operations. These findings seem to suggest that moving R&D can be more complex than moving other organisational functions due to the interconnectivity and the many interfaces to technical and organisational elements both inside and outside the company.

The configuration dimensions emerging from the application of the configuration framework in the R&D domain can help expand the R&D network literature as well as OM considerations for network configurations. This research can, combined with previous research on global networks, be combined to create a more holistic view of the different global networks a multinational corporation engages in.

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